Presentation and Explanation of Medical Decision Models Using the World Wide Web

G.D. Sanders[2], A.D. Dembitzer M.D.[1], P.A. Heidenreich M.D.[3], K.M. McDonald M.M.[3], D.K. Owens M.D., M.Sc.[1,2,3]

[1]Section of General Internal Medicine, VA Palo Alto Health Care System, Palo Alto, CA
[2]Section on Medical Informatics Stanford University School of Medicine, Stanford, California
[3]Division of Health Services Research, Department of Health Research and Policy, Stanford University, School of Medicine, Stanford, California

ABSTRACT

We demonstrated the use of the World Wide Web for the presentation and explanation of a medical decision model. We put on the web a treatment model developed as part of the Cardiac Arrhythmia and Risk of Death Patient Outcomes Research Team (CARD PORT). To demonstrate the advantages of our web-based presentation, we critiqued both the conventional paper-based and the web-based formats of this decision-model presentation with reference to an accepted published guide to understanding clinical decision models. A web-based presentation provides a useful supplement to paper-based publications by allowing authors to present their model in greater detail, to link model inputs to the primary evidence, and to disseminate the model to peer investigators for critique and collaborative modeling.

INTRODUCTION

Clinicians often find published decision analyses difficult to understand and to apply in their clinical practice. Experienced investigators face a different challenge in interpreting a published analysis: how to evaluate the quality of the evidence and assumptions that the authors used to perform the study. As investigators have gained experience with model-based analyses, the problems and the models have grown increasingly complex, yet the economics of publishing create pressure to shorten published articles. Ironically, journals aimed at broad clinical audiences, which publish many analytic studies, often restrict the length of articles more than do specialty journals, whose audience may be better equipped to interpret shorter reports.

These trends contribute to a difficult problem: How can we communicate the findings of a complex modeling study in a way that clinicians and other investigators will find useful? In medicine, quantitative analyses are designed to help clinicians and patients make decisions regarding care (e.g., choice of screening or treatment strategy). Even the best performed study will not attain this goal if clinicians do not understand the analyses, or if they cannot tell how to apply the findings in their practice.

We performed a pilot project to assess the feasibility of using the World Wide Web (WWW) as a supplementary method for presenting and explaining published decision models. The WWW provides two potential advantages for presentation and explanation of decision models. First, the WWW provides the capability to present more information than is available in a published article. Although additional information is helpful only if it is relevant and is presented judiciously, we believe that further detail about a decision model may help readers to assess both the validity and the applicability of an analysis. The second potential advantage is more fundamental: Users can explore a decision model interactively. Thus, a clinician could examine specific assumptions, evidence, findings, and sensitivity analyses, based on her interests. Therefore, we postulated that a web-based format for presenting medical decision models would allow both clinicians and decision analysts an important supplementary medium for presenting and explaining decision models.

In developing our web-based presentation of a decision model, we used published guidelines that provide advice to clinicians about how to read and use a medical decision analysis. Experts in critical appraisal of the medical literature developed these guidelines as part of a widely accepted series of papers that provides advice on how to use the medical literature.[1,2] The guidelines provide a step-by-step approach for reading a decision analysis, for assessing the validity of the analysis, and for determining whether and how to apply the findings to patients. They lead the clinician through a series of questions that help to clarify validity and applicability of the analysis. Our goal was to design a web-based presentation of a decision model that helped a user to answer these questions.

DESCRIPTION OF WEB-BASED PRESENTATION

To demonstrate the feasibility of the WWW as a

0195—4210/96/$5.00

supplementary approach to presenting and explaining decision models, we placed on the web a decision model for evaluating treatment of life-threatening cardiac arrhythmias that we had developed as part of our work in the Cardiac Arrhythmia Risk of Death Patient Outcomes Research Team (CARD PORT). In this section, we describe the model and our web-based presentation. In the following section, we examine each of the questions posed in the guidelines for appraisal of published decision analyses, and note differences in the web-based approach and a traditional paper publication.

CARD PORT Treatment Model. The CARD PORT is a 5-year, multi-institutional study of strategies to prevent sudden cardiac death. Our treatment model compares the effectiveness and the cost-effectiveness of the two leading treatments for patients at risk for sudden cardiac death: implantable cardioverter defibrillators (ICDs) and amiodarone.[3,4] Technical advances and uncertainty about the efficacy of amiodarone therapy make unclear the cost-effectiveness of ICD.

The schematic representation of the web pages, their organization, and the main links among them are shown in Figure 1. This same figure appears as part of our web-based home page, and allows the user to move to any of the other pages, as well as to see the overall organization of the web site. Users can obtain background on specific aims and organization of the CARD PORT. Pages linked to the home page provide definitions relevant to the decision model (for example, this page provides our definitions of the treatment alternatives, of sudden cardiac death, and of perioperative mortality), and model assumptions. Two web pages show an overview of the structure of the model. A page that describes the inputs to the model is linked to the pages that show the structure of the model. The page describing model inputs is in turn linked to evidence tables that describe and critique the studies that we used to develop estimates for the model inputs (see the following section). Additional pages describe the main results and sensitivity analyses. Thus, starting from the treatment-model page, the user can click on any of the branches to get information on the input data and results; to expand the tree (i.e., to see subtrees of the model); or to view references, evidence tables, and results of sensitivity analyses.

COMPARISON OF WEB- AND PAPER-BASED PRESENTATIONS

To illustrate the differences in the web-based and paper-based presentation, we answered the questions posed in the guidelines for using a decision analysis.[1,2] Sections 1 through 3 present these questions, with a discussion of the information available in the alternative formats; we also note potential extensions to our current implementation of the web-based presentation.

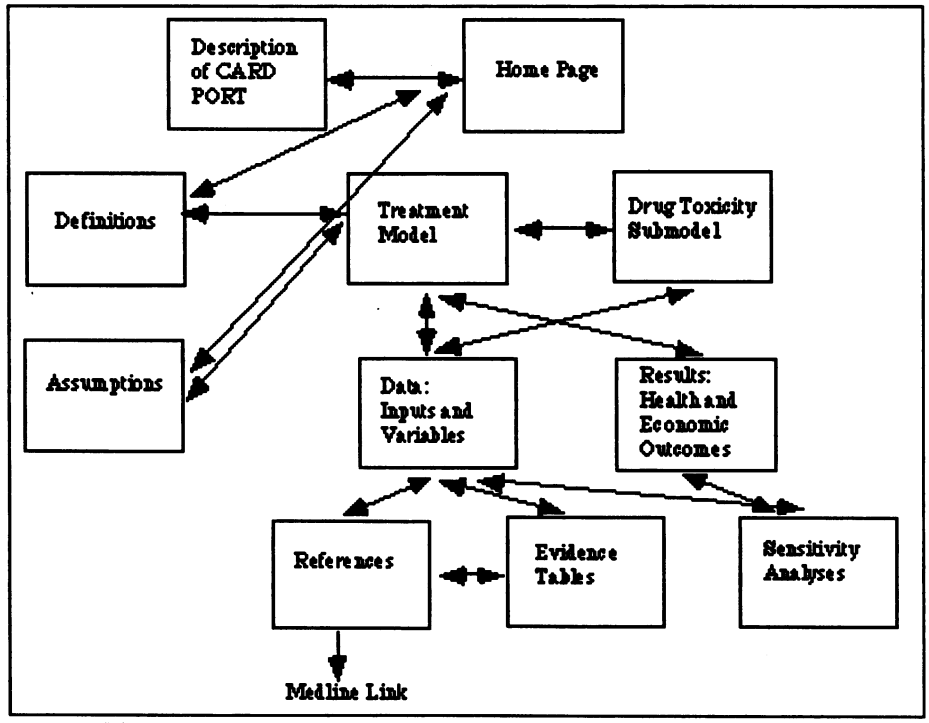

Figure 1. Organization of the WWW decision-model representation.

1. Are the results valid?

a. Were all important strategies and outcomes included? This question asks the clinician to determine whether the structure of the model fits the clinical decision problem. She normally does so by reviewing the published diagrams of the model and determining whether all realistic clinical strategies and relevant outcomes were compared and considered. The paper-based format typically shows a simplified version of the decision tree, and describes in accompanying text which strategies and outcomes are included. Our web-based format shows the same schematic decision tree; here however, the user is able to expand branches of the tree to view further detail. For example, in our model, the user can click on the event branch labeled "drug toxicity," and can thus view the structure of the detailed drug toxicity submodel (with links to data and results). The web-based format also contains links to pages that show the exact model structure, rather than a schematic. These pages enable experienced analysts or clinicians with special interests to examine the actual model structure. Due to the complexity of many large models, examining the model structure is often not possible in published papers.

b. Was an explicit and sensible process used to identify, select, and combine the evidence into probabilities? This question asks the clinician to establish the methodology used by the analysts in obtaining the input data of the decision model. In the paper-based format, authors usually provide a table that lists the main variables, the latter's values, the ranges used in sensitivity analyses, and the sources for the base-case data. In a similar table provided in the web format, the variables are linked to evidence tables that detail the source of base-case data, show calculations (such as adjusting costs to be in 1995 dollars); link ranges of sensitivity analyses to graphs demonstrating the results (a diagram of the input variables and the range of cost-effectiveness over the sensitivity-analyses ranges also is provided); define and display quality ratings of the evidence; and link base-case sources to references, abstracts, and major trials or studies. The ability to link each model variable to the primary data on which its value is based is a substantial advantage of the web-based format, and provides a much richer description of the available data.

c. Were the utilities obtained in an explicit and sensible way from credible sources? This questions tells the reader to determine how the patient utilities were obtained and which measurement methods were used. Both the paper- and web-based formats allow for descriptions of the patient utilities. Our implementation of a web-based presentation provides no particular advantage to the paper-based approach currently, because we do not yet have primary data on patient utilities. It would be possible to link estimates of patient utilities to histograms that show the actual data on which the estimates were obtained. In addition, we hope to link the web format to a program that assesses patient preferences. The clinician could thus determine her patient's preferences, and could compare them to values used for the analysis of the model.

d. Was the potential impact of any uncertainty in the evidence determined? The guidelines suggest that the clinician look for a table "listing which variables were included in the sensitivity analyses, what ranges of values were used for each variable, and which variables, if any, altered the choice of strategies."[1] These elements are typically included in published reports, along with selected sensitivity analyses. A web-based presentation enables the user to view sensitivity analyses on variables that may be of particular interest, given her patient's clinical situation. For example, with our web-based implementation, the user can click on the variable "probability of death given drug toxicity" and be provided with links to a sensitivity analysis that shows the cost-effectiveness of ICD versus amiodarone while the probability of death varies from 0% to 9% [Figure 2]. The sources listed on this web page are also linked to a more detailed description of the study and to their Medline abstract.

2. What are the results?

The second group of questions relate to the results of the study.

a. In the baseline analysis, does one strategy result in a clinically important gain for the patients? If not, is the result a tossup? This question asks the clinician to determine whether any difference between strategies is clinically important. Both the paper and web-based formats allow the user to look at tables describing the health outcomes (and economic outcomes in a cost-effectiveness analysis) for several different risk and cost ranges. In general, because this question is central to the study, the paper format, like the web presentation, should provide a definitive answer.

b. How strong is the evidence used in the analysis? Published analyses usually describe and assess the quality of the evidence for important model inputs. As we noted in regarding question 1b,, the web-based format includes links to evidence tables that describe and critique the studies used to estimate model inputs. Figure 3 shows part of such a evidence table relating evidence for ICD perioperative death. The evidence table gives the study used, a brief description of the

study (study design, population, number of patient, follow-up, evidence rating), the value of the model input used, and comments noting the quality of the data or their applicability for our decision model. The evidence table also notes why a particular value for an input variable was chosen.

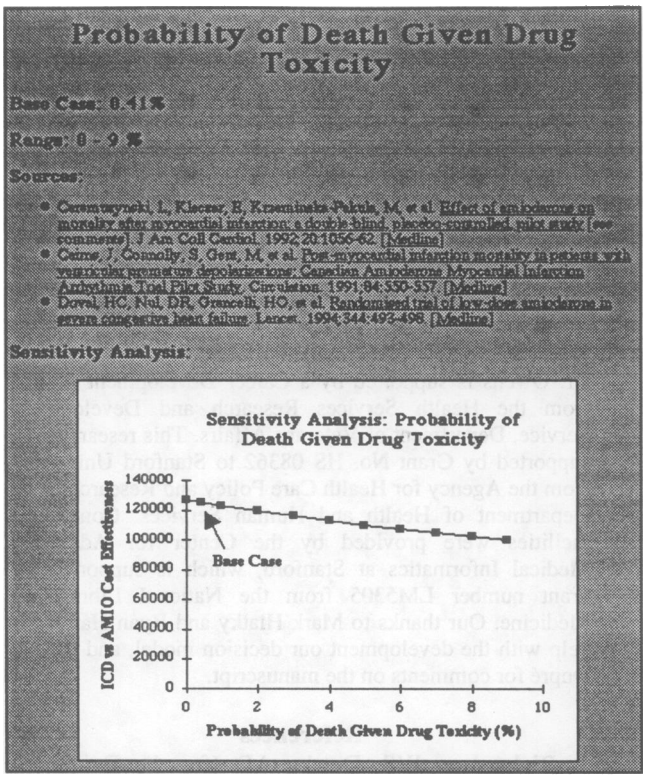

Figure 2: Sensitivity analysis

c. Could the uncertainty in the evidence change the result? This question asks the reader to determine whether changes in model inputs that are uncertain could result in a clinically meaningful change in the results. Both the web and paper formats should include summaries of what the important variables are and what effect the uncertainty has on the decision model's results. Although we have not implemented such a capability, the web format could incorporate executable programs such that a clinician could change a model input and view the resulting model output. This capability would enable a clinician to use patient-specific values for model variables.

3. Will the results help me in caring for my patients?

These two questions help the clinician evaluate the applicability to her patients of the results of the analysis.

a. Do the probability estimates fit my patients' clinical features? This question asks the clinician to establish whether the clinical characteristics of patients on whom the decision analysis was performed are similar to those of her own patient. Both the paper and web formats include definition of the patient population; the web format includes additional sensitivity analyses that reflect different patient groups. If the clinician decides that the base-case data are not representative of her patient, these sensitivity analyses may provide information that helps her to decide how the results might have differed in her patient population.

b. Do the utilities reflect how my patients would value the outcomes of the decision? For many decision problems, the preferred alternative depends on the utilities (or quality of life) associated with alternative treatments. It is, therefore, important that the clinician determine whether her patient's preferences are similar to those used in the decision model. We believe that this question is difficult to answer based on either the paper or the web-based format. For most conditions and treatment, there is little, if any, published information on patient utilities. Unless the clinician is adept at assessing utilities, she may have difficulty answering this question.

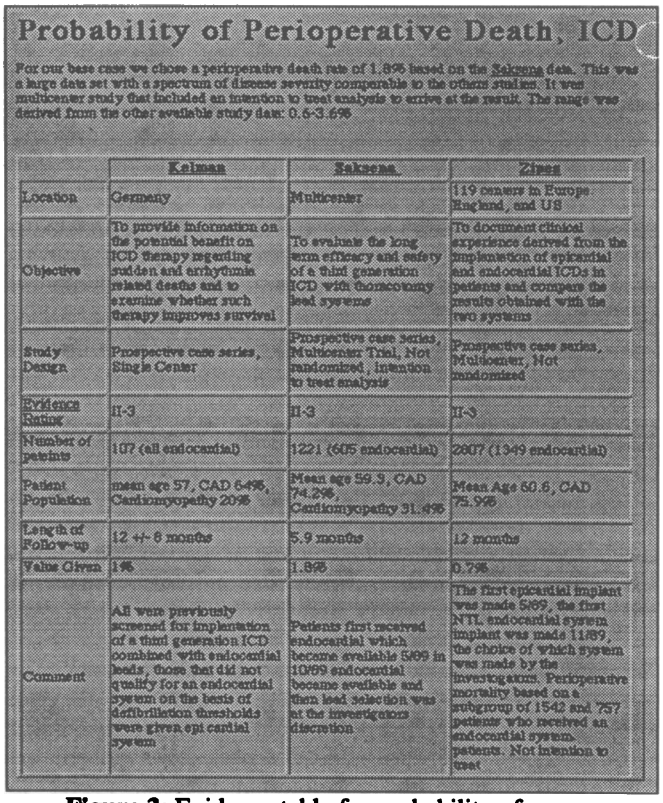

Figure 3: Evidence table for probability of perioperative death

DISCUSSION

In reporting this pilot project, we have described an approach for presenting and explaining a decision analysis on the WWW. The WWW implementation is domain independent, and, although we have described a single decision model, this format should generalize well to other clinical decision models. The structure of the web pages and the hypertext links could remain constant while changing the model-specific input for different domains and decision models. Our web-based implementation provides two advantages relative to published descriptions — the ability to present additional information when useful, and an interactive format that enables users to explore aspects of the model that they find of special interest. Our comparison of the formats with respect to guidelines for reading and assessing published analyses illustrates how the web-based format can supplement the information provided by published reports. Although we believe the web-based presentation is potentially useful to both clinical readers and experienced analysts, a formal evaluation of this hypothesis requires a study that goes beyond our demonstration of feasibility.

Our current implementation does not fully use the capabilities of the WWW. The web-based presentation also allows links to other useful web pages (e.g., links to the clinical guidelines or to on-line resources such as Medline). A web-based presentation could enhance collaborative research projects, because the data and model structure would be easily accessible to collaborators at distant sites. Under this arrangement collaborators or users could suggest additions to evidence tables as further studies are published. A further, though more difficult, extension would enable users to interactively analyze the decision model. This additional capability would enable a web-based presentation to serve as a decision-support tool, as well as an enhanced method for presenting a decision model.

Several obstacles to use of the web-based format deserve mention. Interested clinicians must have access to a computer and web browser, and must be familiar with the WWW. In addition, although the amount of added information is one of the web's greatest advantages, it may also present the clinician with too many options and prove difficult to navigate. Organizing the web pages as we have described, and providing an overview of the data and results that can be expanded at the user's initiative, helps to alleviate this problem. In addition, investigators should consider who will have access to the detailed description. For example, at present, access to portions of our implementation is restricted to members of the CARD PORT, pending peer review and further refinement. Control of access to the model would be particularly important if the web-based format included the capability of decision support. The type of information that should be included in web presentations and the timing of inclusion also are unresolved. Because material would be available on the web that was not contained in published reports, this information would not be peer reviewed. Of obvious concern are questions of copyright infringement if the web-based presentation includes tables or figures from published work. Despite these caveats, the WWW provides a supplementary medium for presentation and explanation of decision models that is more flexible and richer in detail than traditional paper-based presentations. The current CARD PORT decision model can be viewed at http://smi.stanford.edu/people/sanders/SCAMC/.

Acknowledgments

Dr. Owens is supported by a Career Development Award from the Health Services Research and Development Service, Department of Veterans Affairs. This research was supported by Grant No. HS 08362 to Stanford University from the Agency for Health Care Policy and Research, U.S. Department of Health and Human Services. Computing facilities were provided by the Center for Advanced Medical Informatics at Stanford, which is supported by grant number LM5305 from the National Library of Medicine. Our thanks to Mark Hlatky and Ryan Harris for help with the development our decision model, and to Lyn Dupré for comments on the manuscript.

References

1. Richardson WS, Detsky AD (for the Evidence-Based Medicine Working Group). Users' Guides to the Medical Literature, VII: How to Use an Article on Clinical Decision Analysis, A: Are the Results of the Study Valid? *JAMA* 1995; 273: 1292-1295.
2. Richardson WS, Detsky AD (for the Evidence-Based Medicine Working Group). Users' Guides to the Medical Literature, VII: How to Use an Article on Clinical Decision Analysis, B: What Are the Results and Will They Help Me in Caring for My Patients? *JAMA* 1995; 273: 1610-1613.
3. Sanders GD, Harris RA, Hlatky MA, Owens DK. Prevention of Sudden Cardiac Death: A Probabilistic Model for Decision Support. *Proceedings of the Nineteenth Annual Symposium on Computer Applications in Medical Care*, New Orleans LA, October 1995. 258-262.
4. Owens DK, Sanders GD, Harris RA, McDonald KM, Heidenreich PA, Dembitzer AD, Hlatky MA. Cost-Effectiveness of Third-Generation Implantable Cardiac Defibrillators (ICDs) Compared to Treatment with Amiodarone for Prevention of Sudden Cardiac Death. Technical Report. Health Research and Policy, Stanford, CA, 1996.